EECS 270 Fall 2021

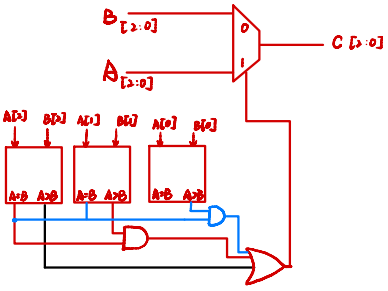
Homework 4

Due Friday, October 8 @ **5:00 PM** on Gradescope

This is an individual assignment, all of the work should be your own.
Write neatly or type and show all your work for full credit.
Have your name and unique name on the front page of your submission.

Submit on Gradescope.
Total Points: 90

1. **[9 points]** *Base Conversion Part 1:* Convert the following decimal numbers to binary, octal, and hexadecimal. If the fraction requires more than 6 digits in the specified base, truncate the fraction to 6 digits.
   a. **[3]** 3499
   b. **[3]** 101.101
   c. **[3]** 867.5309
2. **[10 points]** *Base Conversion Part 2:* Convert the following numbers to decimal. If the fraction requires more than 6 decimal digits, truncate the fraction to 6 digits.
   a. **[2]** ADD_{16}
   b. **[2]** $5AD.BEE5_{16}$
   c. **[2]** 42_8
   d. **[2]** 123.456_8
   e. **[2]** 101010.101_2
3. **[15 points]** *Representations of Negative Numbers:* Convert the following decimal numbers into binary signed magnitude, ones' complement, and two's complement. Represent the number with at least 4 bits, but use the minimum number of bits to do so if it requires more than 4.
   a. **[3]** -3
   b. **[3]** 21
   c. **[3]** -36
   d. **[3]** -256
   e. **[3]** 64



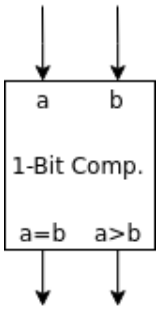
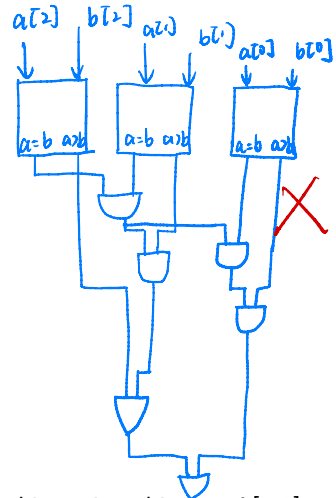


Figure 1: One-bit comparator



4. **[16 points]** *Comparators:* Design and draw a digital logic circuit with two 3-bit unsigned inputs A[2:0] and B[2:0], and a 3-bit unsigned output C[2:0]. The output should be the greater of the two inputs (the circuit can output either input when they are equal). You may use instances of the 1-bit comparator in Figure 1 as well as AND, OR, and NOT gates, along with a 3-bit 2-1 MUX.

1. **[9 points]** *Base Conversion Part 1:* Convert the following decimal numbers to binary, octal, and hexadecimal. If the fraction requires more than 6 digits in the specified base, truncate the fraction to 6 digits.
   a. **[3]** 3499
   b. **[3]** 101.101
   c. **[3]** 867.5309

a) $3499_{10} \rightarrow 110\,1101\,0101_2$ $\quad 3499_{10} \rightarrow 6653_8$

$\frac{110}{6}\ \frac{110}{6}\ \frac{101}{5}\ \frac{011}{3}$

$3499_{10} \rightarrow DAB_{16}$

$\frac{1101}{D}\ \frac{1010}{A}\ \frac{1011}{B}$

2|3499 ... 1 (LSB)
2|1749 ... 1
2|874 ... 1
2|437 ... 0
2|218 ... 1
2|109 ... 0
2|54 ... 1
2|27 ... 0
2|13 ... 1
2|6 ... 1
2|3 ... 0
2|1 ... 1
0 (MSB)

b) $101.101_{10} \rightarrow 1100101.000110_2$ $\quad 101.101_{10} \rightarrow 145.06_8$

2|101 ... 1 (LSB)
2|50 ... 1
2|25 ... 0
2|12 ... 1
2|6 ... 0
2|3 ... 0
2|1 ... 1
0 (MSB)

MSB	101 x2	
0	202 x2	
0	404 x2	
0	808 x2	
1	616 x2	
1	232 x2	
0	464 x2	
LSB	0	

$\frac{001}{1}\ \frac{100}{4}\ \frac{101}{5} . \frac{000}{0}\ \frac{110}{6}$

$101.101_{10} \rightarrow 65.1F_{16}$

$\frac{0110}{6}\ \frac{0101}{5} . \frac{0001}{1}\ \frac{1000}{15}$

A B C D E F
10 11 12 13 14 15

2. **[10 points]** *Base Conversion Part 2:* Convert the following numbers to decimal. If the fraction requires more than 6 decimal digits, truncate the fraction to 6 digits.
   a. **[2]** ADD_{16} A:10 B:11 C:12 D:13 E:14
   b. **[2]** $5AD.BEE5_{16}$
   c. **[2]** 42_8
   d. **[2]** 123.456_8
   e. **[2]** 101010.101_2

a) $10 \times 16^2 + 13 \times 16^1 + 13 \times 16^0$

$= 2560 + 208 + 13$

$= 2781_{10}$

b) $5 \times 16^2 + 10 \times 16^1 + 13 + 11 \times 16^{-1} + 14 \times 16^{-2} + 14 \times 16^{-3} + 5 \times 16^{-4}$

$= 1280 + 160 + 13 + 0.6875 + 0.054688 + 0.00342 + 0.000076$

$= 1453.745681_{10}$

c) $2 \times 8^0 + 4 \times 8 = 32 + 2 = 34_{10}$

3. **[15 points]** *Representations of Negative Numbers:* Convert the following decimal numbers into binary signed magnitude, ones' complement, and two's complement. Represent the number with at least 4 bits, but use the minimum number of bits to do so if it requires more than 4.
   a. **[3]** -3
   b. **[3]** 21
   c. **[3]** -36
   d. **[3]** -256
   e. **[3]** 64

	magnitude	signed magnitude	1's complement	2's complement
a) -3	0011 ✓	1011 ✓	1100 ✓	1101
b) 21	10101 ✓	010101 ✓	010101 ✓	010101 ✓
c) -36	100100	100100	011011 ✓	011100
d) -256	100000000	100000000	011111111	100000000

5. **[15 points]** *RCA Propagation Delay:*

   a. **[5]** Calculate the maximum propagation delay for both S and C_{out} in the full adder circuit in Figure 2. Assume a XOR gate takes 2 ns, an OR gate takes 3 ns, and an AND gate takes 4 ns.

   b. **[5]** Using the propagation delays you found for S and C_{out} in part a, calculate the maximum propagation delays for C_4 and S_3 for a 4-bit ripple carry adder as shown in Figure 3.

   c. **[5]** Using the maximum propagation delays you found in part a, calculate the maximum propagation delays for $C_1 3$ and $S_1 2$ be for a 13-bit ripple carry adder.

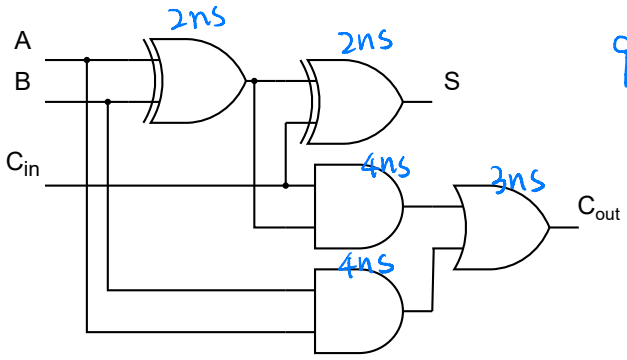


Figure 2: Full adder circuit

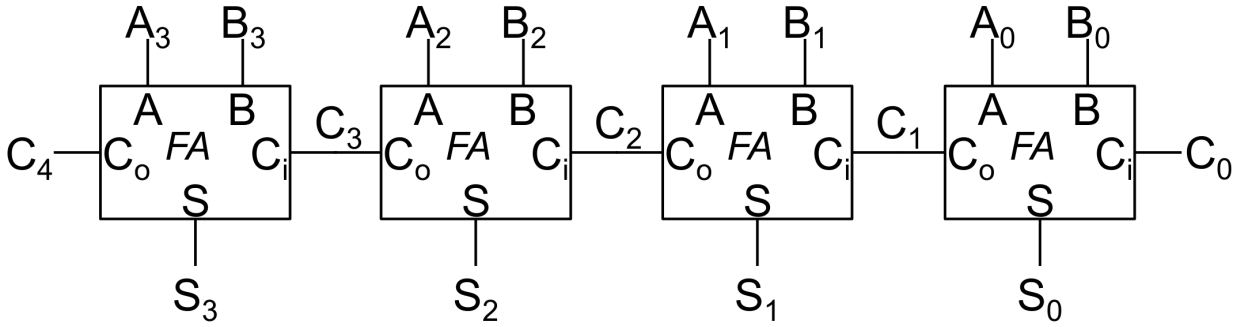


Figure 3: A 4-bit ripple carry adder circuit.

6. **[25 points]** *Binary Addition and Subtraction:* Perform the following operations on the 6-bit numbers (which are in signed 2's compliment representation), with a 6-bit sum/difference. Indicate if the result has overflowed. Additionally, write down the decimal representation of the operation (e.g. -8 + 1 = 7).

   a. **[5]** 001100 + 110001

   b. **[5]** 001110 + 011001

   c. **[5]** 100011 + 101100

   d. **[5]** 001101 - 000110

   e. **[5]** 100011 - 100001